Discovery of Planetesimal Belts in the β Pictoris System

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We made spatially resolved spectroscopy of the disk of β Pic in the N-band with the Cooled Mid-Infrared Camera and Spectrometer on the 8.2-m Subaru Telescope. From the obtained low resolution ($R \sim 250$) spectra, we found that the 10 μm emission arising from different (small/large/crystalline) silicate grains shows different spatial distributions: micron-sized amorphous grains and crystalline grains are concentrated in the disk center, while submicron-sized amorphous grains have distribution peaks at 6, 16, and 30 AU from the disk center. Since these submicron grains should be blown out from the system by radiation pressure, the peaks correspond to the locations of grain replenishment and thus are conceivable as planetesimal belts like the asteroid belt in the Solar System. These belts may have been formed by gravitational perturbation of planetesimals in unstable orbits with a possible large planet. One possible orbital radius of such a planet is 12 AU. The large amorphous grains are also being replenished in the same belts, but they infall toward the central star due to the Poynting-Robertson drag. They will be crystallized by thermal annealing near the star. These processes lead to the observed spatial distribution of large and crystalline grains. This is the first observational evidence that reveals the precise locations of the grain replenishment and silicate crystallization in a debris disk. In particular, the discovery of the planetesimal belts is important in understanding the formation of planetary systems.